Satisfying Student Outcomes 3 and 5 of ETAC, A Different Approach

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1.0 Abstract

Criterion 4 of the self-study report that ABET/ETAC requires for starting the process of Engineering Technology programs accreditation states: “The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the Student Outcomes are being attained. The results of these evaluations must be systematically utilized as input for the program’s continuous improvement actions.”

One of the major abilities required is that the ETAC student outcomes emphasize is the ability to work in and lead technical teams. This ability should be reinforced by technical communications skills as can be noted from ETAC outcomes 3 and 5 detailed below.

ETAC outcome 3 reads: “an ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to identify and use appropriate technical literature,” whereas Outcome 5 reads: “an ability to function effectively as a member as well as a leader on technical teams.”

Programs normally follow separate and sometimes distinct approaches to assess these two outcomes. Furthermore, the assessment of each of the two ETAC outcomes might be looked upon as being discrete rather than integrated abilities of students.

The Bachelor of Science in Mechanical and Manufacturing Engineering Technology (BSMMET) program have used different set of student outcomes. These 11 outcomes align up not only to the five ETAC students outcomes, but also to the American Society of Mechanical Engineering (ASME) criteria and the criteria of the Society of Manufacturing Engineering (SME).

The accreditation of the BSMMET program requires that both professional association criteria to be met since the program title includes both, the mechanical and the manufacturing.

Student Outcome 11 of the BSMMET reads: “Apply written, oral and graphical communication, demonstrating an ability to identify and use appropriate technical literature, and function effectively as a member as well as a leader on technical teams.”

This paper is a presents a method to assess and improve the abilities of students satisfying both student outcomes 3 and 5. In addition, it introduces and analyzes two methods of assessment, a direct method using a rubric administered by the instructor and an indirect method using a survey completed by the students. Data from at least two semesters are presented and analyzed to discuss the concept and the evidence needed by ETAC. The paper demonstrates how capstone project courses could be used as the platform for this assessment approach.

2.0 Mapping BSMMET Program Student Outcomes to ETAC Student Outcomes

As mentioned in the abstract, our program has adopted eleven student outcomes that were designed to satisfy ETAC student outcomes, ASME criteria, and SME criteria. The reason for that is that both professional organizations serve as evaluators in the ETAC accreditation process, since the title of the program includes both mechanical and manufacturing.

In this paper we are concentrating mainly on the ETAC five student outcomes, which read

1. an ability to apply knowledge, techniques, skills and modern tools of mathematics, science, engineering, and technology to solve broadly-defined engineering problems appropriate to the discipline;
2. an ability to design systems, components, or processes meeting specified needs for broadly-defined engineering problems appropriate to the discipline;
3. an ability to apply written, oral, and graphical communication in broadly-defined technical and non-technical environments; and an ability to identify and use appropriate technical literature;
4. an ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results to improve processes; and
5. an ability to function effectively as a member as well as a leader on technical teams

We have mapped our eleven student outcomes to these five as presented in the following table:

Table 1. Alignment between of BSMMET and ETAC student outcomes.

BSMMET Student Outcomes	ABET Student Outcomes					Courses Used in Assessment
	1	2	3	4	5	
1.Apply principles of Geometric Dimensioning, Tolerancing, drafting and computer aided analysis	X			X		TME2103, TME2003, TME4113
2. Select, set-up, and calibrate instrumentations	X			X		TME2103, TME2203, TEE4224
3. Use Solid Mechanics, Statics and Dynamics in Mechanical system design needs	X			X		TME3113, TME3223
4. Solve problems in Differential and Integral Calculus	X			X		MCS1414, MCS3324
5. Apply Materials Science, Select and measure Strength of Materials	X			X		TME4103, TME3223

6.Analyze Manufacturing Processes and Systems	**X**	**X**				TME3063 TME4413
7. Apply Principles of Thermal Sciences	**X**					TME3204
8. Evaluate Currents and analyze Electrical Circuits and Control	**X**			**X**		TEE3103, TEE 4214
9. Apply Engineering Design processes, Tooling & Assembly Techniques to meet required standards	**X**	**X**			**X**	TME4113, TME3353, TIE3063, TIE4115
10. Perform Quality analysis, Continuous Improvement, and Industrial Management procedures	**X**	**X**	**X**			TME3333, TIE3163, TME5343
11. Apply written, oral and graphical communication, demonstrating an ability to identify and use appropriate technical literature, and function effectively as a member as well as a leader on technical teams			**X**		**X**	TME3353, TIE4115

As indicated in red, BSMMET student outcomes 9 and 11 were restructured to capture what ETAC student outcome 3 and 5 indicates. Also, that was linked in the table with a “X” in red. The TME3353 is a new class that was developed and introduced to enhance the support of both outcomes 9 and 11 of the BSMMET. Furthermore, this course was added as one of the prerequisites to the senior project to enhance the leadership training.

3.0 Action Taken To Satisfy ETAC Student Outcomes 3 and 5

ETAC elaborated in the visiting report to our campus that Student Outcomes 3 can be satisfied by applying them to “narrowly- defined" engineering problems.

We started by reassessing and auditing all our 11 student outcomes to verify that all ETAC student outcomes, ASME criteria and SME criteria are satisfied properly and directly. The process led to change two of the eleven Outcomes, namely Outcome 9 and Outcome 11. The previous and updated outcomes read as follows:

Previous outcome 9: Follow up product design, tooling & assembly processes

Current outcome 9: Apply engineering design processes, tooling & assembly techniques to meet required standards

Previous outcome 11: Communicate technically and efficiently in engineering presentations and reports

Current Outcome 11: Apply written, oral, and graphical communication, and function effectively as a member as well as a leader on technical teams

To provide evidence of appliance, the Senior Project TIE4115 course description has been modified to highlight and emphasize the inclusion of teamwork experience.

The updated course description reads: "This course is structured to enhance teamwork experience in designing and developing products. The course fosters and expands entrepreneurial concepts by utilizing all of the student's educational and professional experience. Student teams will follow product development cycle used in industry. Students team will practice effective problem solving, conflict resolutions and develop leadership skills."

The goal of the course as stated in the syllabus attests that the student will be able to function effectively as a member as well as a leader on technical teams to satisfy the course learning objectives. This language is strictly and explicitly required by ETAC.

The syllabus for TIE4115 was updated by addressing all aspects of the ETAC student Outcomes 3 and 5 along with the associated criteria of ASME and SME. The new syllabus stated the goal and course learning objectives as follows:

> *Course Goal*: The student will be able to function effectively as a member as well as a leader on technical teams to satisfy the following course learning objectives:
>
> 1. Apply acquired knowledge from curriculum disciplines in a product development cycle from brainstorming to a deliverable product.
> 2. Perform an IP search, market survey, and production analysis hitting a target ROI.
> 3. Create entrepreneurial mindset process necessary to start a business.
> 4. Present designed product as a team to the industrial advisory board that is video recorded.

To avoid any shortcoming from the previous outcome 9, the outcome has been modified as stated above and a new course has been introduced. The new course title is Engineering Design and Standards TIE3353. This course, along with existing computer design graphics course and the process of design followed by students in their senior project course, will emphasize the application of the design methodology and practice.

The TIE3353 course description states: "This course will prepare students to engage in engineering design process and follow the required engineering standards. Topics include details of the three stages of the engineering design process: establishing needs, developing design and presenting solutions. Also included will be a comparison between scientific and engineering design methods. The following engineering standards topics will also be covered: history and purpose, role of governments in standards, standards and codes, types of standards, standards interpretation, and characteristics of good standards."

This course was introduced as directed study in spring 2023 and is offered as a regular course in fall 2023.

4.0 Assessment of Leadership as Indicated in ETAC Student Outcomes 3 and 5

A plan to collect data and evaluate them was adopted as part of the regular assessment process of updated outcome 11 which reads: "Communicate and function effectively as a member as well as a leader on technical teams."

The data collection plan utilizes two tools about teamwork, a rubric that the instructor will use to evaluate students' involvement in the teams (direct assessment), and a form that students will have to complete. The form to be completed by students was designed to capture the extend that teamwork experience helped students to acquire teamwork skills (indirect assessment).
Both tools were applied in two successive semesters, fall 2022 and spring 2023. The number of students in the senior project course was 10 and 15 respectively.

The rubric was designed to evaluate six attributes of teamwork throughout the senior project teams: team member role, time management, contributions, attitude, leadership and participation, and written, oral and graphical communication. Each of those criteria was given four levels of expectation, exceeding worth 20 points, meeting worth 15 points, developing worth 10 points and beginning to develop worth 5 points. The maximum possible total score is 120.

The indirect assessment form that was given to students to rank (scale 1 through 5, where 5 is the highest) five areas benefiting from teamwork experience, these five areas are: problem solving approach, technical and graphical communications, negotiation within team, teamwork presentation experience and teamwork product design. Copies of both forms are reprinted below:

Student Name: **Evaluation of Teamwork Rubric** **Semester:**
Outcome11: Communicate verbally, graphically and function effectively as a member as well as a leader on technical team.

Expectation / **Attributes**	**Exceeding** 20 points	**Meeting** 15 points	**Developing** 10 points	**Beginning to develop** 5 points
Team member role	Always listens carefully to team members. Demonstrates patience and encourages team members Collaboration. Engages in a group decision making process and shares input effectively.	Consistently listens to team members and responds with appropriate input. Supports the efforts of the team and is respectful.	Usually listens to, shares with, is patient with, and supports the efforts of the team members. Makes some decisions without team input.	Occasionally listens to team members. Shares input but struggles to collaborate (either takes control, does not participate
Time Management	Facilitates team's use of time throughout the project to ensure deadlines are met. Volunteers to assist other team members with tasks.	Uses time well throughout the project to ensure things deadlines are met. Assists other team members with tasks if the need arises.	Tends to procrastinate, but always gets things done by the deadlines. Team does not have to adjust deadlines	Struggles to get things done by the deadlines. Team has to adjust deadlines or work responsibilities as a result.
Contributions	Works with team to establish common purpose and goals. Facilitates the development of an action plan. Carries out assigned	Understands common goals. contributes ideas to develop a plan of action and by carrying out assigned work.	Contributes mostly useful ideas. Follows plan of action and completes tasks.	Does what is required.

	work and supports others in completing their tasks.			
Attitude	Always has a positive attitude about the project, task(s), and working with a team.	Has a positive attitude about the project, task(s), and working with a team?	Usually has a neutral attitude about the project, task(s), and working with a team.	Has a neutral attitude about the project, task(s), and working with a team.
Leadership & Participation	Facilitates team assignment of responsibilities, ensuring that work is shared. Shows initiative and good organizational skills.	Takes responsibility when asked or elected, shows good organizational and leadership skills within the team.	Takes some responsibility for project. Shows leadership on certain aspects of the project.	Does what is required but hesitates to or does not take leadership. OR Takes over the project entirely.
Written, oral & graphical communication	Project reports are very well written, presentations are very well designed and delivered and graphs were meaningful and address the required issues	Project reports are well written, presentations are properly designed and delivered and graphs were acceptable and explain the required issues	Project reports are written in acceptable language, presentations are somewhat well designed and delivered and graphs acceptable	Project reports are not well written, presentations are not well designed and delivered and graphs were not to the standard and did not address the required issues
Total				
Final Score:		Final Score as a percentage:		

Indirect Assessment of Team work					
Please Rank (1 through 5) the extend that teamwork Experience helped achieve the following goals					
Rank 5 indicates extremely helpful and Rank 1 not helpful					
	Rank				
	5	4	3	2	1
Problem solving approach					
Technical and Graphical Communication					
Negotiation within team					
Teamwork presentation experience					
Teamwork Product design					

The collected data were processed into summary data tables and analyzed by the instructor and the assessment coordinator of the department. Below are the summarized data and the evaluation for the two semesters:

4.1 Fall 2022 assessment of teamwork

4.11 Direct assessment data from rubrics. Table 2 was produced from the data collected for this semester.

Table 2. Direct assessment of student outcome 11 based on the rubric, fall 2022

Attributes	Number of students exceeding expectations score 20	Number of students meeting expectations score 15	Number of students developing expectations score 10	Number of students beginning to develop skills score 5	Total
Team member role	1	4	3	2	10
Time management	1	3	6	0	10
Contributions	0	2	4	4	10
Attitude	4	2	3	1	10
Leadership & participation	2	4	3	1	10
Written, oral & graphical communication	2	1	5	2	10
Total	10	16	24	10	60
Percentage	17%	27%	39%	17%	100%

Based on the goals set by the assessment process, the teamwork outcome 11 should be satisfied if the percentage of students scoring 20 (Exceeding expectation) or 15 (meeting expectation) will be 60% or better. Also, the percentage of students scoring 5 (Beginning to develop) should not exceed 10% of the student in the class.

The data from table indicates that the goals were not met in fall semester. The percentage of students exceeding or meeting expectation was found to be 44%, whereas the percentages developing skills in teamwork was 39%.

Fig. 1. below clearly indicates that 39% of the students in fall 2022 were in the stage of developing skill needed to satisfy outcome 11.

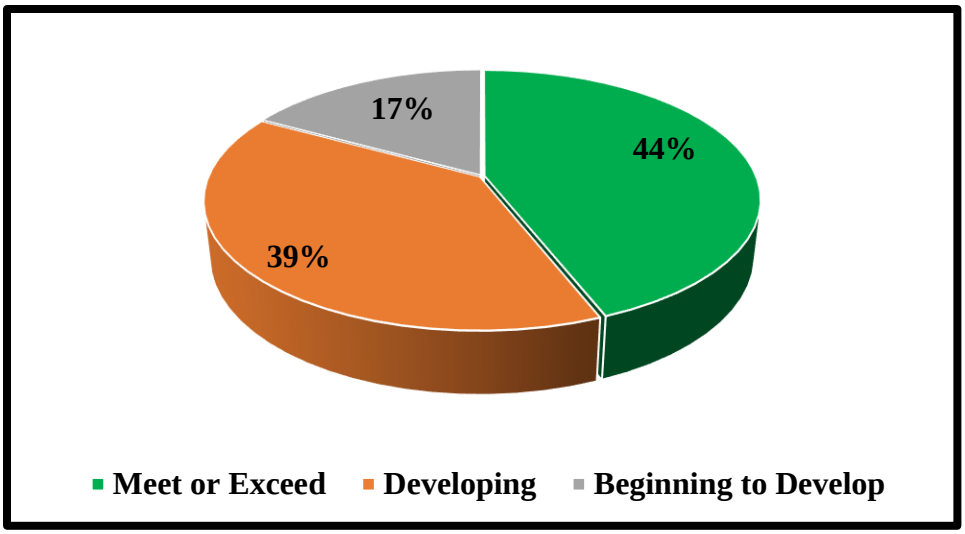

Fig. 1. Direct assessment of student outcome 11 based on the rubric fall 2022.

According to data collected from the rubrics, the average percentage score of all the students' scores was 59% which is shy of the 65% average that could be considered accepted.

4.1.2 Indirect assessment data from student's questionnaire. The data collected are summarized in Table 2 below:

Table 2. Indirect assessment of teamwork fall 2022.

Please Rank (1 through 5, 5 being the highest and 1 being the lowest) the extend that teamwork Experience helped achieve the following goals						
Rank 5 indicates extremely helpful and Rank 1 not helpful						
Skills	Rank					
	5	4	3	2	1	
Problem solving approach	3	6	1			10
Technical and Graphical Communication	0	2	4	4		10
Negotiation within team	0	2	5	3		10
Teamwork presentation experience	2	4	1	3		10
Teamwork Product design	0	2	8			10
Total	5	16	19	10	0	50
Percentage	10%	32%	38%	20%	0%	100%

The data in the above table somewhat agrees with the direct assessment data from the rubrics. The Percentages of students ranking skills with 5 and 4 totaled to 42% with the highest percentage of rank 3 was 38% as we can see from Fig. 2.

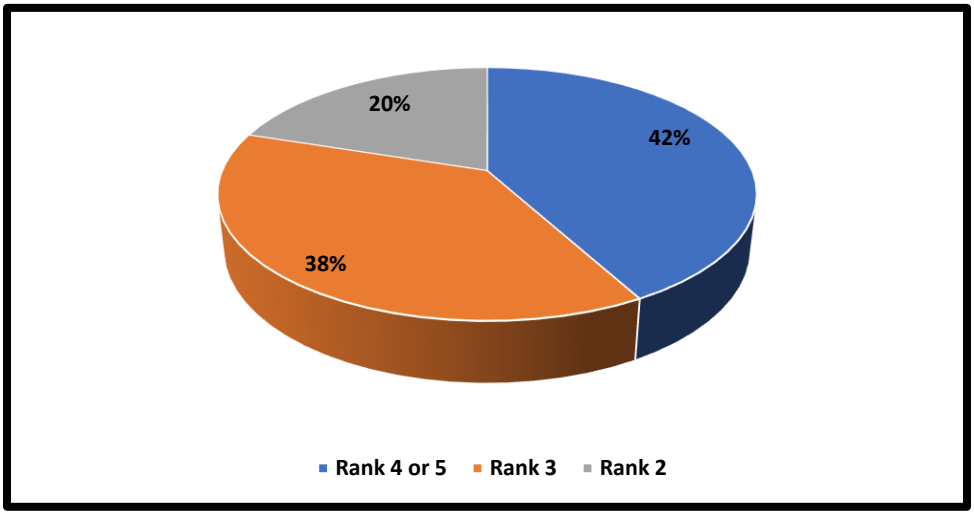

Fig. 2. Percentages of student's ranking for skills acquired fall 2022.

After discussion between the instructor of the course and the assessment coordinator, it was agreed to invite a speaker to lecture about teamwork practices and importance in industry. The lecture should be delivered no later than the third week of the semester starting spring 2023.

4.2 Spring 2023 Assessment of Teamwork

As mentioned earlier, 15 students enrolled in TIE4115 this semester, compared to 10 in the previous semester. Table 3 summarizes data collected from the rubrics completed by instructor for each of the 15 students.

Table 3. Direct assessment of leadership based on the rubric spring 2023.

Criteria	Number of students exceeding expectations score 20	Number of students meeting expectations score 15	Number of students developing expectations score 10	Number of students beginning to develop skills score 5	Total
Team member role	1	8	5	1	15
Time management	0	13	2	0	15
Contributions	3	5	3	4	15
Attitude	1	8	6	0	15

Leadership & participation	0	6	9	0	15
Written, oral & graphical communication	3	2	5	5	15
Total	8	42	30	10	90
Percentage	9%	47%	33%	11%	100%

The data in Fig. 4 indicate evidence of improvement in the percentages of students scoring 15 points on the rubric, hence meeting the expectations. The percentage moved up from 27% to 47%. Although the percentage of students scoring 20 moved down to 9% from 17% in the previous semester, but the total percentage of students scoring 20 or 15 moved up from 42% to 56%. A closer look at the percentages can be made using Fig. 3.

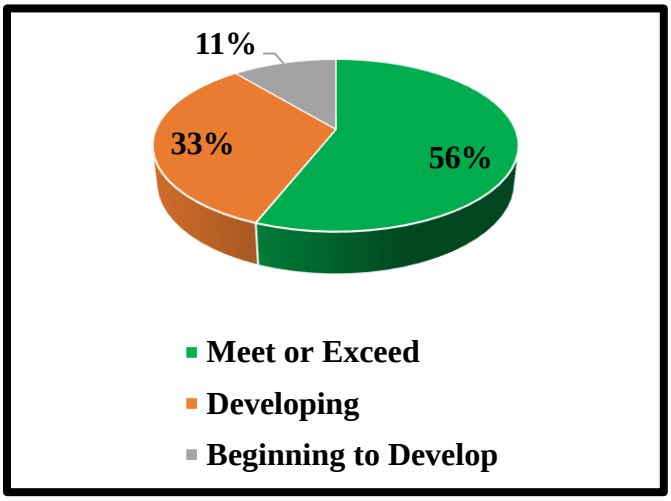

Fig. 3. Percentage of student teamwork evaluation scores based on the rubric spring 2023.

Despite the improvement, the goal is to increase the percentage of students scoring 15 or better to 65% as a general target. This percentage was 63% in spring 2023.

A comparison between fall 2022 and spring 2023 is presented in Fig. 4.

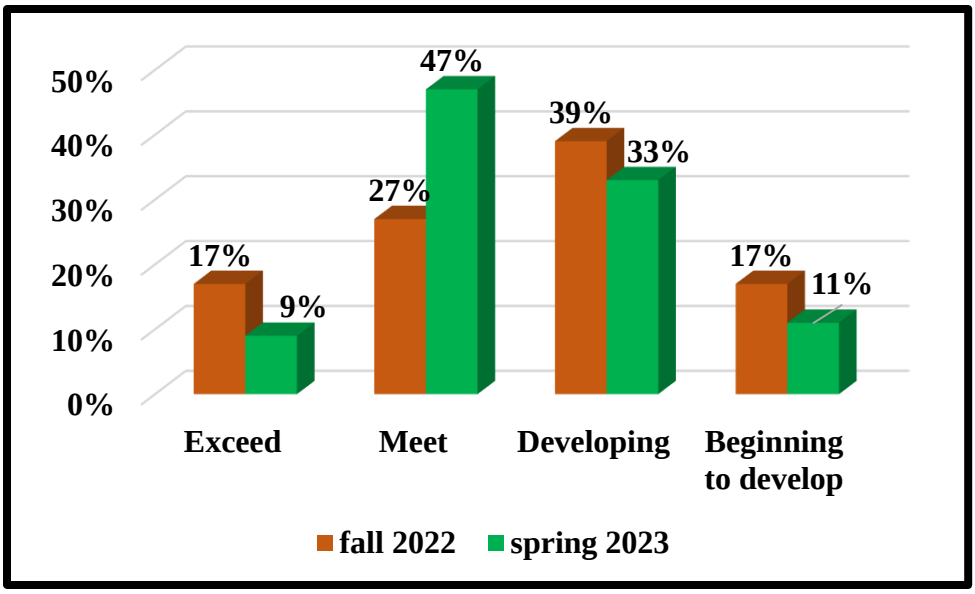

Fig. 4. Comparison between fall 2022 and spring 2023 direct assessment data.

4.2.2 indirect assessment data collected from the forms completed by students. This set of data presented in Table 4 does not indicate a significant change in how students rank their lesson learned through the teamwork exercise of the senior project. The percentage of students ranking 5 to the skills acquired improved to 13%, while rank 4 secured the same 32% as in fall 2023. Rank 3 share was 36% of the students. Fig. 5 below provides an overview of the percentages of ranks.

Table 4. Indirect assessment of teamwork spring 2023.

Please Rank (1 through 5, 5 being the highest and 1 being the lowest) the extend that teamwork Experience helped achieve the following goals					
Rank 5 indicates extremely helpful and Rank 1 not helpful					
	Rank				
	5	4	3	2	1
Problem solving approach	4	5	5	1	
Technical and Graphical Communication	0	4	5	6	
Negotiation within team	0	3	8	3	1
Teamwork presentation experience	5	5	4	1	
Teamwork Product design	1	7	5	2	
Total	10	24	27	13	1
Percentage	13%	32%	36%	17%	1%

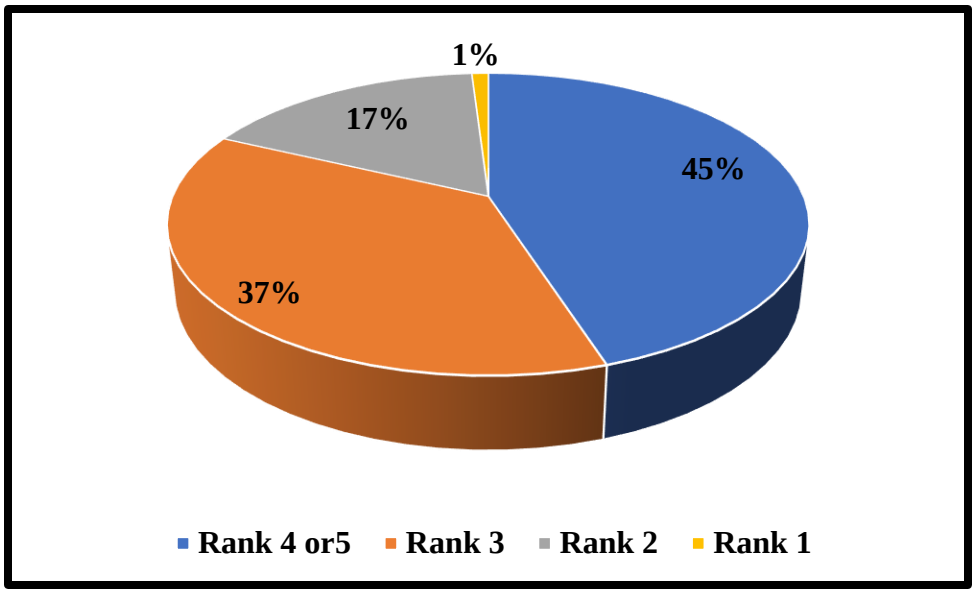

Fig. 5. Percentages of students' ranking for skills acquired spring 2023.

Fig, 6 compares the indirect assessment data from fall 2022 and spring 2023.

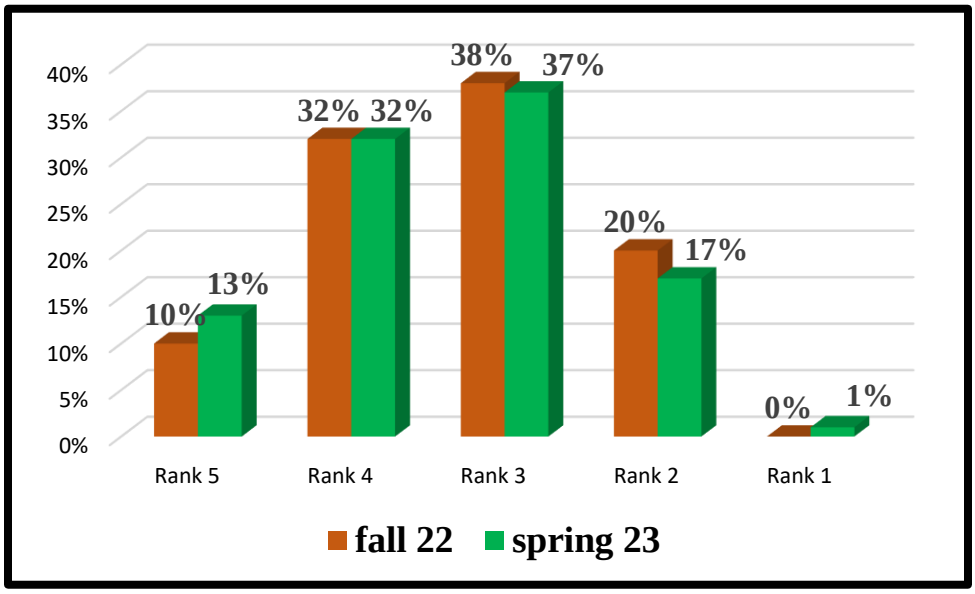

Fig. 6. Comparison between fall 2022 and spring 2023 indirect assessment data.

An in-depth discussion of these results took place between the instructor, the department assessment coordinator and faculty of the department that engages their students in some teamwork activities like small reports or lab experiments.

The data-based conclusion from the meeting led to recommending the following improvements:

- The presentation of the external lecturer on teamwork in real industrial environment was efficient and it should be repeated. A suggestion was adopted to have more than one external presentation and record them so they might be used as available references to students involved in teamwork projects.

- Although all students in the senior project have taken the proper technical management courses which include information about technical team structures and project logistics, it was agreed that the introduction of Engineering Design and Standards course TIE3353 and use it to be a prerequisite or at least corequisite at the beginning of the senior project course will be of great help in the enhancement of teamwork experience of the students. TIE3353 would also improve the team's capability in designing their senior project products.

- A recommendation to encourage students to work as a team rather than individuals to write reports when appropriate in courses like Manufacturing Engineering Processes or Lean Manufacturing.

5.0 Conclusion

The approach used in the paper to satisfy ABET/ETAC student outcomes 3 and 5 was sufficient and was accepted by the ETAC team.

Since ABET/ETAC Student Outcomes are changed every few years, satisfying ETAC/ABET Student Outcomes along with the associated professional organizations criteria has and will continue to represent a challenge to academic programs applying for ABET accreditation. We recommend that programs should try developing their own list of student outcomes that could be linked to the required ABET teams and professional organizations' criteria.

Adopting ABET Student Outcomes of ABET might seems safer to some programs, but the changing of these outcomes and the existence of program criteria makes the compliance a not always a straightforward process.

Crafting our own program student outcomes that clearly include all ABET student outcomes and associated criteria, provided the programs with a certain level of stability in the assessment process and continuous improvement practices. We provided proof of this.

Since the paper was written to reflect a practical approach to a specific problem facing programs seeking ABET accreditation, the work presented above did not directly referenced a particular article, yet we have to admit that we have benefited from the knowledge provided by several papers addressing the issues of the paper. Below is a list of the papers that we read and reviewed.

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Biographies

SABAH ABRO earned a bachelor's degree from Baghdad University, followed by a master's degree from the United Nations Institute in the Middle East, another master's degree in Britain, and ultimately a PhD in Belgium. In the USA, Sabah was certified in Six Sigma at the master Blackbelt level. His teaching journey traversed the Middle East, with roles in Iraq and Jordan, and included guest lecturer positions in Kuwait and Morocco. He assumed various roles, such as faculty member, regional consultant, department chair, and acting dean. Notably, he contributed to a groundbreaking curriculum in manufacturing engineering education before joining Lawrence Tech University (LTU, he transitioned from a full-time role in 2000 and now serves as the chair of the department of Engineering Technology.

KEN COOK is a professor and former chair of the Department of Engineering Technology at Lawrence Technological University. Ken is a registered professional engineer, a certified clinical engineer, holds 28 patents and degrees from DeVry Technical Institute, Lawrence Technological University, Wayne State University, and Oakland University. He was executive vice president and chief engineer for Vultron/Trans Industries. He also started and managed the Clinical Engineering Department at William Beaumont Hospital, Royal Oak. Ken became an adjunct professor at Lawrence Tech in 1965. Ken's entrepreneurial-focused senior projects class is the capstone course where students generate project ideas, research, design, manufacture, and assess the market for inventive products. He also has a long side career in magic.